ACCURATE RANGE FREE LOCALIZATION IN MULTI-HOP WIRELESS SENSOR NETWORKS

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Special dedication

I dedicate this work to my beloved mother, father,wife and daughter.

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All praises is to ALLAH Subhanahu wa ta'ala for bestowing me with health, opportunity, patience, and knowledge to complete this research. May the peace and blessings of ALLAH Subhanahu wa Ta'aala be upon Prophet Muhammad (Sallallahu alayhi wa sallam).

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ABSTRACT

To localize wireless sensor networks (WSN)s nodes, only the hop-based data have been so far utilized by range free techniques, with poor-accuracy, though. In this thesis, we show that localization accuracy may importantly advantage from mutual utilization, at no cost, of the information already offered by the advancing nodes (i.e., relays) between all anchors (i.e., position-aware) and sensor nodes join up. In addition, energy-based informant localization approaches are generally established corresponding to the channel path-loss models in which the noise is mostly expected to shadow Gaussian distributions. In this thesis, we signify the applied additive noise by the Gaussian mixture model and improve a localization algorithm depend on the received signal intensity to attain the greatest likelihood location, estimator. By employing Jensen's inequality and semidefinite relaxation, the originally offered nonlinear and nonconvex estimator is relaxed into a convex optimization difficulty, which is able to be professionally resolved to acquire the totally best solution. Moreover, the resultant Cramer–Rao lower bound is originated for occurrence comparison. Simulation and experimental results show a substantial performance gain achieved by our proposed localization algorithm in wireless sensor networks. The performance is evaluated in terms of RMSE in terms of three algorithms WLS, CRLR, and GMSDP based on using the Monte Carlo simulation with account the number of anchors that varying from anchor=4 to anchor =20. Finally, the GMSDP-algorithm achieves and provides a better value of RMSEs and the greatest localization estimation errors comparing with the CRLR algorithm and WLS algorithm.

ABSTRAK

Untuk menyetempatkan nod rangkaian sensor wayarles (WSN), hanya data berasaskan hop yang telah digunakan setakat ini dengan teknik bebas jarak, dengan ketepatan yang kurang baik. Dalam tesis ini, kami menunjukkan bahawa ketepatan penyetempatan mungkin menjadi kelebihan daripada penggunaan bersama, tanpa sebarang kos, maklumat yang telah ditawarkan oleh nod yang sedang berkembang (iaitu) di antara semua sauh (iaitu, sedar kedudukan) dan nod sensor. Di samping itu, pendekatan lokalisasi informan berasaskan secara amnya ditubuhkan sepadan dengan model saluran kehilangan saluran di mana bunyi kebanyakannya dijangka akan menyebarkan pengagihan Gaussian. Dalam tesis ini, kami menandakan kebisingan tambahan yang digunakan oleh model campuran Gaussian dan meningkatkan algoritma penyetempatan bergantung kepada keamatan isyarat yang diterima untuk mencapai lokasi kemungkinan besar, penganggar. Dengan menggunakan ketidaksamaan Jensen dan kelonggaran, yang pada asalnya ditawarkan penganggar bukan linear dan nonconvex santai menjadi kesukaran pengoptimuman cembung, yang dapat ditentukan secara profesional untuk memperoleh penyelesaian terbaik. Selain itu, terikat Cramer-Rao yang dihasilkan berasal dari perbandingan kejadian. Hasil simulasi dan eksperimen menunjukkan keuntungan prestasi yang besar dicapai oleh algoritma penyetempatan cadangan kami dalam rangkaian sensor tanpa wayar. Prestasi ini dinilai dari segi RMSE dari segi tiga algoritma WLS, CRLR, dan GMSDP berdasarkan penggunaan simulasi Monte Carlo dengan memperhitungkan bilangan sauh yang berbeza dari sauh = 4 hingga sauh = 20. Akhirnya, algoritma GMSDP mencapai dan memberikan nilai RMSE yang lebih baik dan ralat penganggaran lokalisasi yang paling besar berbanding dengan algoritma CRLR dan algoritma WLS.

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LIST OF SYMBOLS

WSNs	Wireless sensor networks
MEMS	Microelectromechanical Systems
GPS	Global Position System
ToA	Time of Arrival
TDoA	Time Difference of Arrival
AoA	Angle of Arrival
MDS	Multi-Dimensional Scaling
LNNE	Localization Node System
RAM	Random Access Momery
ROM	Read-Only Memory
RSS	Received Signal Strength
RSSI	Received Signal Strength Indicator
MAC	Media Access Control
IP	Internet Protocol
A/D	Analoge Digital Converter
LOS	Line of Sight

TDD	Time Division Duplex
FDD	Frequency Division Duplex
ISI	Inter Symbol Interference
FFT	Fast Fourier Transform
MPDU	MAC Protocol Data Units
LEACH	Low Energy Aware Clustering Hierarchy
EAC	Energy –Aware Clustring
PSO	Practical Swarm Optimization
MSR	Maximum Sum Rate

CHAPTER 1

INTRODUCTION

1.1 Introduction

Wireless sensor networks (WSNs) have gained worldwide attention in recent years. A WSN consists of spatially distributed autonomous sensors inexpensive with limited resources that cooperatively monitor a deployed region for physical or environmental conditions, such as temperature, sound, vibration, pressure, motion, and pollutants also can monitor and acquire physical information in the distribution detection area in real time.

The small and energy-saving and sensors, manufacturing, for micro-electromechanical systems (MEMSs) technology has become the latest developments in technical and economic sense. A sense node measures, as well as gather information on the environment, the basis of the decision of some local, through the medium of wireless LED sinks (or base stations) for the sensible information. WSNs-year, sensor nodes, network management, and much more information at the crossroads of WSN applications, monitoring, target tracking, and Geographic important for navigation, etc.

A sensor, a simple white with a Global Positioning System (GPS) module, can have the status of wireless sensor networks for all of the sensor nodes equipped with GPS modules are very expensive [1]. An alternative solution glands or anchor nodes as a beacon nodes, only a limited number of modules for the GPS equipment, and their

positions [2]. If a beacon nodes in the localization algorithm called glands of unknown modules to other nodes Positioning (GPS) can help you. Depending on the type of input data based on the range of the restrictions proposed for WSNs algorithms and can be divided into a number of independent groups. Many WSN routing algorithms require the sensor nodes in the status information. However, some serious research environment, where necessary, it is difficult to accommodate the sensor nodes. As a result, the nomenclature is not based on algorithms, such as between the network node and the beacon signal strength is estimated absolute distance measurements show that the unknown nodes based services (RSSI) [3,4], the calculation of the time Location (ToA) [5] , Time Difference of Arrival (TDoA) [6, 7], or Angle of Arrival (AoA) [5, 8, 9].

Among the range of restriction of freedom of nodes requires no distance or angle. The technique of local and hop-counting technique: This method can be divided into two categories. The center of gravity for the implementation of the algorithm is simple and easy, but the localization of nodes based on the percent of the beacon is placed. Another popular series of free localization algorithm DV-Hop is suggested by the Hradec Kralove and Nath. DV-hop, and each beacon lighthouse on the other nodes in the network and the Euclidean distances and the hop-count information, and its average hop count for length.

An unknown nodes and beacon nodes to estimate distances and calculate the estimate of the length of the average lateration hop to use. As a result of the scheme is based on the nomenclature of the distance between nodes in the corner, but only a certain number of free support for additional equipment as there is no restriction of Hops depends on the communication between the nodes in the data. As a result, according to the nomenclature for free Another advantage of the scheme, it is an adult; Data communication between the nodes in the environment were not affected. Based on the range of the localization algorithm is simple, free hardware series is superior to the algorithm for support against the lower consumption and noise bandwidth, range free algorithm is more widely used. Multi-Hop methods for the calculation of a communication application. communication nodes, multi-dimensional scaling (MDS),

you can use information communication. Suits and neural network component using different neural networks, wireless sensor networks can be used to improve the localization accuracy. Two well-known range of algorithms restriction-free LNNE compared with the center of gravity, and DV-hop, and sensor nodes determine the bride carried restraint system, only LNNE network connectivity information, use of a neural network-based localization algorithm, LSNN.

The LNNE performance ratio of the beacon, investigating the effects of network density and coverage hole. Many studies have tried to address the issues of WSNs range restriction. Most of them are difficult to determine the required number of anchor nodes and sensors require a number of visits and the calculation of the variable lateration method used. The basic characteristics of a WSN networks, batteries or energy harvesting and power consumption constraints. Energy suppliers, for example, the ability to cope with as a hub, and perpetuum mobile behavior (stability), some nodes (glands MWSNs not to see higher), the glands, and to a large extent on the reliability of nodes in the uniqueness and environmental protection to withstand harsh Terms of use Cross-layer design, the possibility of dismissal [10,11,12]. As a result, according to the nomenclature of free methods of calculation algorithms, regional and Hop. This means there is no need for additional equipment there is only one node identification and cost effective methods of communication information can be used by many, but the result is not accurate. Integrated Services Digital Network, the network a few more ways to communicate with each other to describe the number of nodes is limited. In fact, networks are used to transfer the package to their desired destination. For the Multi-hop features, and can be carried out with the energy associated with each node.

1.2 Problem Statement

Wireless sensor network applications depend mainly on the success of many of the node localization algorithm. WSNs location discovery that in addition to most of the existing literature on the specific position involves some of the nodes [4], [5], [9]. Their location, and then used to determine any other sensor nodes. The issue in the houses of

the wireless sensor networks nodes or all pairwise spatial relationship between the measurement data is the identification of a set of sensor nodes. Often, the restrictions on literature, WSNs can be categorized in three different aspects of the [2]. Unfortunately, the number of sensor nodes, all the nodes in the network can not be a simple solution for adding GPS to the following [2].In the presence of dense forests, mountains or other obstacles that block the line-of-sight from GPS satellites, GPS cannot be implemented.

- The power consumption of GPS will reduce the battery life of the sensor nodes and also reduce the effective lifetime of the entire network.
- In a network with large number of nodes, the production cost factor of GPS is an important issue.
- Sensor nodes are required to be small. But the size of GPS and its antenna increases the sensor node form factor .

For limitations of this reason, the GPS requires a good decision, and the algorithm should be efficient, responsive, and can operate in different environments. The need for technological progress in the areas of energy, day after day, can not solve the problem of these calculations is included in the wireless communication. However, this large-scale integrated circuits and sensor networks with hundreds, or even a very small brain, which will allow the implementation of low-cost, battery life and wireless sensor and Again nodes [14].

GPS devices are limited by the conditions on the GPS signals, but the cost of the environment to prevent the use of large-scale sensor networks [15], [13]. In addition, to reduce the cost of the proposed algorithms. If a node is wrong, then this error has increased to the general network and the further nodes; As a result, the location of the anchor nodes [12] wrong information can be propagated. The main disadvantage of limiting the freedom of GPS communication studies, as well as the cost of self-building for participation in the course of each node cancer increases with the increasing convergence of time and concludes that the combination of the local coordinate system.

1.3 Objectives

The objectives of this project are:

i. To investigate the existing localization schemes for wireless sensor networks.

ii. To propose a GPS-free localization scheme for the local coordinate system formation where nodes cooperate with each other.

iii. To evaluate the performance of GPS-Free localization by previous studies and make simulations to measure their performances.

1.4 Project Scope

The project scope will be focusing on two major components which are represented as follows:

I. We validate and illustrate our theoretical results by Monte Carlo simulations. These are conducted to compare under the same network settings the R2-normalized LEEs (NLEE)s achieved by the proposed algorithm and three of the best representative localization algorithms currently available in the literature.

II. We derive the average LEE achieved by our localization algorithm and studied its behavior and properties. Motivated by the fact that the LEE is a more practical metric than its average, we investigate in this section its statistical properties more thoroughly for the sake of further highlighting the proposed algorithm's accuracy.

1.5 Thesis Outline

Chapter 1 gives an overview of the project design. It covers the introduction Wireless sensor networks, problem statement, objectives, and the scope of work in this project.

Chapter 2 focuses on literature review about the insights about the major challenges and issues in wireless sensor network. ensor node, energy conservation techniques that used in a previous researches, particle swarm optimization methods in WSN, and localization algorithms.

Chapter 3 discuss the methodology present the localization systems for wireless sensor networks (WSN). This chapter study the modeling a sensor by improve the topology flexibility and accurateness of multi-hop localization. Moreover, we establish the possibility of node coordinates.

Chapter 4 study and implement the simulation results for range free localization proposed a novel localization algorithm. In addition to, aanalysis the channel path-loss for the additive noise in RSS measurement is modeled according to three approaches namely, CRLR algorithm, GMSDP- alogrithm and WLS algorithm.

Chapter 5 the researcher summarizes the contributions based on the proposed technique that used the algorithm scales for large numbers of nodes and provides convergent localization over time, even with errors introduced by motion actuators and distance measurements.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter to understand the problem extension of the major issues and challenges in the field of wireless sensor and sensor network energy consumption of different types of methods used in previous surveys. Energy storage, WSN and particle concept of limiting the swarm optimization methods and algorithms for sensor network. Also discussed in this chapter, the researcher node architecture and its application to various restrictive methods, as well as scientific and research directions. For this chapter, the WSN nodes Localizations algorithms in wireless sensor networks and GPS-free range localization in limit sensor nodes will be the introduction of the basic concept. In this chapter, wireless sensor networks in different management schemes can be compared among the algorithms, various GPS-free addition.

2.2 The Components of the Sensor Nodes

In The sensor nodes in the network software and hardware parts. Is a key part of the hardware components of the network and radio-transceiver sensors, processing, energy and effort. Wireless sensor networks software is a part of some of the software used to manage nodes in the main Tinyos, Nano Rk and Contiki, in this chapter, the researcher hardware components.

1. **Sensors**. There are two kinds of sensors: analog and digital sensors. Analog sensors distribute the information in a way a regular procedure or analog waves. After the data signal applied to the human readable information processed by the management of the site of the central processing unit. digital sensors and digital form directly to the human readable information. After the converted data will be processed and the information, then the administrator [16] and then sent for further processing.

2. **Processors**. Design Wireless Sensor Networks is one of the major hardware component parts, and there are many different types of memory used for data. I / O devices and the rest of the integrated circuit, [17].

3. **Random-access memory (RAM).** The RAM read-only memory (ROM), all in the field of wireless sensors nodes [19] is used to maintain the existing system running, but before sending him back to RAM stores data received from the sensors, the most sensitive to sleep mode. When operating in sleep mode, it does not consume the power. involved in other activities such as sleep mode, time synchronization, [18].

4. **Radio Transceiver**. The wireless network used to transfer data from other sensors [20] Transceiver radio frequency signals are used. One of the main purpose of the transceiver to establish a connection with one of the sensor nodes is very important. Here, wireless sensors must be used for the transceiver function of the energy. transceiver has 4 modes of operation: from sleeping in the empty state, and [17], as shown in the Figure 2.1.

5. **Power Unit.** This is the greatest essential portion of wireless sensor networks. receiving node signals and requires the transfer of power, because the power unit can not perform no function. You can not stop a unit of electrical power, sensor and network dies determines the life of the sensor network.

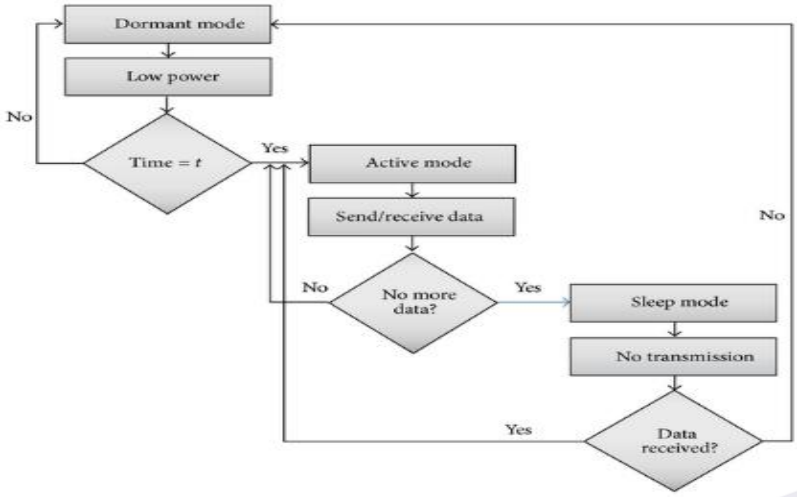

Figure 2.1 : Transition of sensor node in different modes

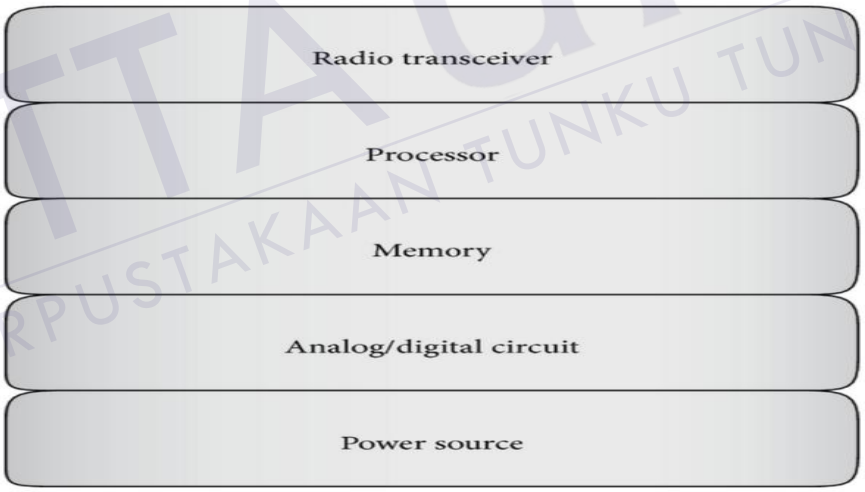

Figure 2.2 : Typical architecture of sensor node [18].

2.2.1 The Function of WSN

The wireless sensor network, the main task of the data for a specific purpose, and in some areas, this information may be sent. Therefore, the main thing in this process collects and sends data to a central control unit that the sensor is to know about the exact location or assessment. This type of information is extremely useful for the wireless network operator, and its processing and then, depending on the use of wireless sensor networks can be explained. According to the technique, using sensor networks, localization Wireless sensor networks is the main objective should be the same. Wireless sensor networks are the mistakes the majority of the schemes [21], served as the moderator will require some nodes. The Global Positioning System (GPS) is available to the public is one of the popular positioning technologies, and the weakness of this technique, basically, every network and installation of various kinds of high energy consumption and high cost. The main functions of the network location of the sensor, sending, tracking, and target signal, there is every reason to say that identification of these glands.

The process of limiting sensor networks, sensor information, is an important function. As one of the important task of sensor networks, localization and tracking an object has attracted a lot of research efforts. Such buildings in the cities and bio-chemical spills such as the distribution of large objects regularly, usually, there is much more than its sensing range of the sensor. a continuous distribution of objects and spatial extent of the control and movement sensors, and will require a large number of cooperation. This cooperation has developed highly sophisticated communication and information. Therefore, identification of objects, and the representative of the wireless sensor network is very important to control and sensor networks is an important scientific problem. Based on the above, the scientific and GPS localization failure of efforts to reduce energy consumption and costs, and GPS modules and parts can be installed in the field of monitoring the use of a lighthouse, only a few nodes (glands) that it can be concluded. Therefore, the glands of GPS-proposed method of restriction

of freedom. The process of the place is located within the wireless network and the network is a network of self-restraint.

2.2.2 Localization Schemes in WSN

Localization wireless sensor used for network sensor nodes in order to determine the exact or approximate method and algorithm. Many of the works and studies on this subject. This restriction is to develop a method of energy-saving and low-cost method will be a very enviable, effective restrictions or other requirements on the network the ability to scale [41].

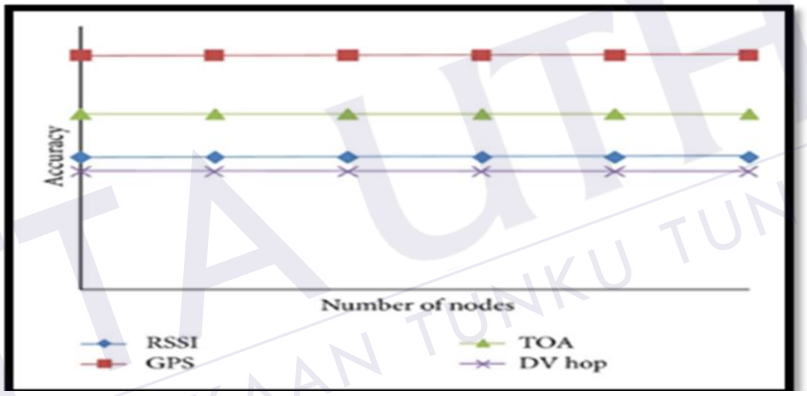

Figure 2.3: Accuracy comparison of different localization [41].

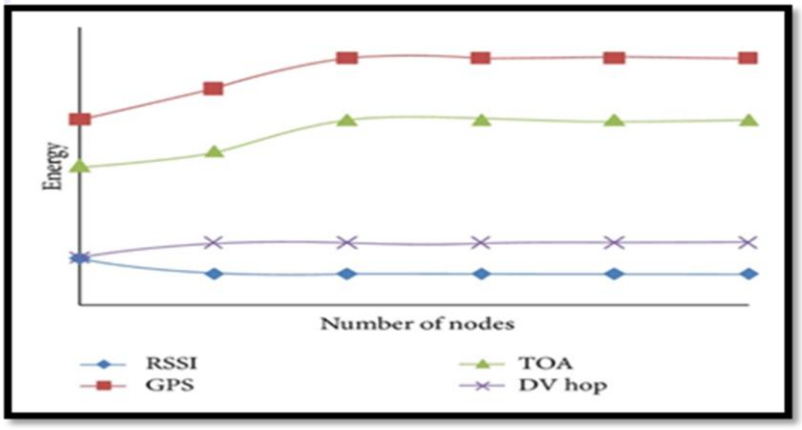

Figure 2.4: Energy efficiency comparison of different localization [41].

Currently, the restrictions of different algorithms are used for static sensor nodes and mobile sensor nodes. Scales used for localization include: Received Signal Strength (RSS), Time-of-Arrival (TOA), Time-Difference-of-Arrival (TDOA). These mechanisms are opposite in time of accuracy and energy consumption as shown in Figures 2.3 and 2.4.

Assessment in the wireless sensor network nodes, usually in the other nodes in the network based on the measurement of some features of the radio signal received by the radio frequency based on the methods. Some of these indicators, such as the angle (AOA) is very important for the international assessment of the time (toa), received signal strength (RSS). Some algorithms (AoA) would depend on the angle of the data [32-38]. This information is usually possible to determine the direction of the transmitter network, radio network, or carefully work together using Arrays. This optical communication methods in order to collect more information AoA. These techniques provide a platform, with a few (3-4), allowing one to hear the alarm signal transmitted. Among those who came to sign with various receivers, his analysis of the key or time, these signals can be found in the corners. recipient of the received signal strength of a received signal strength indicator (RSSI) circuit is defined as the voltage measured. In many cases, received signal strength as measured equivalently.

The signals transmitted signal strength during the checkpoint or the total energy requirements, but also with each receiver [46] can be measured, so the Wireless sensor nodes and their connections with neighboring sensor nodes. RSS method is mainly only on low-cost equipment depends on the distance between the coarse-grained assessment: On the other hand, is throwing and TDoA methods, additional equipment can evaluate the cost of higher truth and distance. In addition, due to restrictions on the cost of this equipment and the large distance between the sensor network evaluation equipment for the evaluation of all the sensors and the exact location is not suitable for [43]. Going Time Difference (TDoA) is a common mechanism of hardware. TDoA schemes, each node is equipped with speakers and headphones. The system in some other audible frequencies to use, but the use of ultrasound. However, the general mathematical method is not dependent on specific hardware. In TDoA, transmitter sends the first

radio message. At that time, some of the main range, t_{dela} (wait for it to zero), and after that, the speaker may be causing the "chirps" for example. If nodes are listening to the radio signal, they heard t_{radio} their turn on the microphones and note the current time. Their microphones chirp to identify a pattern, they went back to the present time, t_{sound}. After winning their t_{radio}, t_{sound} and t_{dela} in the distance between themselves and the audience, and radio waves, acoustic pulse, the pulse transmitter is considerably faster than the sound of the calculation. Localization of each network or service will determine the placement of geometric, the connection between the two nodes (local and network unfocalized) measurement is achieved by using the method of evaluation. In other words, to measure the distance between the target network nodes and the angle is determined through mathematical analysis. At the moment, the following methods are used in many wireless sensor networks, a drawback.

a) Literation is measured to estimate the distance between nodes in the location.

b) Angulation Disability will be evaluated to determine the angle between the glands.

c) Trilateration with three nodes in the network, measured by the distance measurement. According to this view, the intersection of the three circles unfocalized a node status is, to a point.

d) Multilateration. Nodes are used in the calculation. Gaze, two local nodes in a network unfocalized at least two angles are measured to evaluate the state of the target node [22] is a mechanism that will be used. All of the above methods to limit the absolute truth, because of the location or the global coordinates to a specific area. Another type of evaluation of localization, localization, and their absolute coordinate system, all appliances, including a range between themselves and the neighboring devices are called. Limit the absolute benchmark could turn into a family of brothers in their homes. However, the second absolute not always have access to their homes [23].

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